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# Distribution and abundance of silver hake eggs, larvae, and juveniles, and environmental conditions off the Nova Scotia Shelf in August-October 1978

by

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## Introduction

Silver hake is an abundant commercial species on the Nova Scotian shelf. The catches of this species are subject to sharp fluctuations due to variable recruitment of year classes. Therefore, the study of the factors controlling the silver hake strength on the Nova Scotian shelf is of a great theoretical and practical importance.

At the meeting of the Canadian and Soviet scientists held in Ottawa in June 1977, it was agreed that the joint study of the factors controlling the silver hake strength on the Nova Scotian shelf should be initiated. The first expedition was carried out in 1977 on SRTM-8024 FOTON. Both parties were satisfied with the results of the joint venture and agreed that such research activities should be continued on the Nova Scotian shelf in the summer-fall period of 1978.

This paper presents the results of studies on the silver hake spawning efficiency in August-October 1978 during the SRTM-8004 VYKHMA cruise.

## Material and Methods

In August and September 1978 two subsequent ecological surveys of the Nova Scotian shelf were made covering the area southwest to northeast. Complex studies included the water temperature measurements and zoo- and ichthyoplankton sampling at 148 standard stations (fig. 1). Bathythermograph casts were made to determine the water temperature to within ± 0.1°C.

Ichthyoplankton was sampled using the smaller bongo model with the gauze mesh size of 0.570 mm. A total of 296 samples was collected.

The sampling for zooplankton was also made by the small bongo fitted with the gauze with the mesh size of 0.076 mm. The hauling was made within the 0-100 m stratum at the wire angle of 45°. Above the depths of less than 100 m the plankton was sampled within 5 m off the bottom to the surface. The velocity of the ship was the minimum possible and ranged between 2 and 2.5 knots. The bongos were set at 50 m/min and retrieved at 20 m/min. In October 1978 a trawl survey of the fry was made, which encompassed 100 stations (fig. 2). A 13.6 m trawl with the codend fitted with a fine mesh netting (5 mm mesh size) was used as a fishing gear. Half an hour hauls were made in the near-bottom layer at the velocity of 3.5 knots. All pertinent data were recorded on trawl logs.

The zoo-and ichthyoplankton samples have been exampled ashore in the Laboratory of the Northwest Atlantic, AtlantNIRO. The number of silver hake eggs and larvae under $m^3$ was counted and the seston biomass estimated. The species composition and abundance of the zooplankton at selected stations were determined and the contents of silver hake stomachs examined to study the composition, intensity and selectivity of their feeding.

## Distribution and abundance of eggs and larvae

The massive spawning of silver hake on the Nova Scotian shelf takes place between August and September (Noskov, Karaulovsky, Romanchenko and Sherstiukov, 1978; Sauskan, Serebriakov, 1968).

During the first survey (6-28 August) the eggs were found in three areas: on Browns and Banquereau Banks and on the Sable Island shoal (fig. 3), that is, in shallow waters where silver hake generally forms aggregations in summer. The largest recorded egg aggregation was on the shaols south-west of Sable Island. Another large aggregation was detected in the southern part of Browns Bank and an insignificant one on the Banquereau Bank slopes. In this period the larvae were numerous west of Sable Island; in small numbers they occurred on Banquereau Bank, whereas in the Browns Bank samples no larvae were available (fig. 4).

In September the eggs and larvae were abundant west of Sable Island (fig. 5, 6).

From the above-stated it follows that the Nova Scotian silver hake stock mostly spawns west of Sable Island, where the commercial silver hake aggregations had been observed. The water circulation promotes favourable conditions for the silver hake spawning and formation of dense larva concentrations west of Sable Island. A detailed scheme of the geostrophic current (Sigaev, 1978) shows the presence of local gyrals. So, in August an anti-cyclonic gyral (descending water) can be observed over Emerald and Middle Banks, whereas northwest of Sable Island up to Nova Scotia coast there stretches a vast zone of cyclonic (rising water) gyral.

The number of eggs under $m^2$ averaged 29 (1-626) in August and 13 (1-515) in September. Total recorded abundance of the silver hake eggs all over the area was $51{,}3 \cdot 10^{11}$ in August and half as much ($23.0 \cdot 10^{11}$) in September. The silver hake eggs in the Browns Bank, Sable Island shoal and Banquereau Bank areas were at maturity stages III, II and I respectively.

The number of larvae under $m^2$ averaged 20 (1-416) in August and 14 (1-239) in September. Total recorded abundance of the silver hake larvae was $35{,}8 \cdot 10^{11}$ in August and $25{,}6 \cdot 10^{11}$ in September. The length of larvae in the catches ranged between 2 and 18 mm, that is, together with newly hatched larvae of 2-3 mm the specimens of about 20-25 days from hatching occurred with the 18 mm body length. This fact is indicative of lengthened spawning of silver hake in 1978. In the Sable Island shoal area the length of the larvae averaged 4.60 mm in August (2-11 mm) and 5.38 mm (2-18 mm) in September; in the Banquereau Bank area the mean length of the larvae was 5.19 mm (3-8 mm) in August and 6.42 mm (3-12 mm) in September (fig. 7).

The above data indicate that the spawning in the Sable Island shoal area lasts untill September inclusive, and in the Banquereau Bank area it evidently comes to an end by the middle of September.

## Distribution and abundance of silver hake fry

As is evident from the results of the October 1978 trawl survey of the Nova Scotia shelf, the silver hake fry were abundant in the near-bottom layer and were easily accessible to an an experimental fry trawl. On Browns Bank the fry occurred insignificantly, their major concentrations being recorded in the Nova Scotian trough (fig. 8), where they were confined to the depths of 100 to 200 m with the temperature of 6-8°C. The largest catch per haul (2 900 sp.) was taken west of the Sable Island shoal at the station occupied between 43°20'N and 63°11'W. The body length of the fry was 2 to 7 cm; in 4W it averaged 2.82 cm and in 4X - 3.02 cm (fig.9).

The detrmination of the abundance index was the main object of processing the experimental results. It was estimated as 135 sp. per mile$^2$.

## Weather conditions

In general, the weather conditions in the summer-fall period of 1978 favoured the conduction of research activities. The Nova Scotian shelf area experienced the influence of cyclons centered somewhat north of the shelf and east-oriented anti-cyclons moving from the USA coast. South-west and north-west waves and winds of 3-4 units of velocity were prevailing.

Hydrological conditions can be characterized as the interaction of warm waters of the oceanic origin, related to the Gulf Stream, cold Labrador waters and the Nova Scotian shelf waters proper. The surface layer temperature fluctuated between 11 and 20°C (fig. 10-12). The thickness of this layer increased towards the coast. The mean recorded depth of its lower boundary was 25 m. The water temperatures in this layer varied depending on the seasonal meteorological conditions. Thus, for example, the temperatures were 14-20°C in August, 11-18°C in September and 11-15°C in October. Marked horizontal temperature gradients in the Scotian shelf and warm oceanic waters, related to the Gulf Stream, were recorded over the continental slope. Besides, the Labrador water massives with low temperatures of 0-0.3°C over the north-east Nova Scotian shelf to 8°C in the south-western part of this area are clearly pronounced in the water temperature distribution pattern. The above conditions generated a complex picture of the water temperature distribution for the 50-100 m layer (fig. 13-19). The near-bottom layer (200 m and more) contained warm (5-10°C) oceanic waters, which make their way inside the shelf limits through deep-water canyons and hollows.

## Zooplankton

A decrease in the seston biomass in the southwest-northwest direction of the investigated area could be observed on the Nova Scotian shelf in August. Most dense recorded seston biomass aggregations (50-263 $g/m^2$) were in the Roseway, Sambro and Emerald Bank areas (fig. 20). In the northeastern part of the area under study the seston biomass seldom exceeded 50 $g/m^2$. The mean weighted seston biomass was 55.8 $g/m^2$.

In September, the seston biomass distribution pattern over the investigation area is more uniform (fig. 21). Isolated seston aggregations (50-114 $m/m^2$) were observed at single stations on Emerald and Banquereau Banks and on the Sable Island shoal. In September the mean weighted seston biomass was half as much as in August and amounted to 26.2 $g/m^2$.

The species composition and abundance of the zooplankton were determined at selected stations, where the abundance of the silver hake larvae was high. The zooplankters of Gen. Oithona and Centropages and copepod nauplii prevailed at the stations in August and September.

## The feeding of larval silver hake

The feeding of larval silver hake on marine organisms begins as soon as they attain the body length of 2 mm (Samyshev, Ptitsina, 1976). The major food components for larval hake in August and September were copepodite stages of Paracalanus spp., Pseudocalanus spp., Clausocalanus spp., Oithona spp. and the nauplial stages of these species (tables 1 and 2). As is evident from the tables, copepodites are predominant in the larval hake stomachs during the very early stages of larval development, constituting 31.4 to 62.0% by weight. The proportion of large food organisms in larval hake feeding increases with their growth. So, for example, larval hake with the body length over 6 mm fed on comparatively large copepodite stages ranging from 0.91 to 1.07 mm in length (see tables 1 and 2). From table 3 it can be seen that both the number of feeding larvae and feeding intensity were relatively high. The mean index of food consumption by larval hake in August and September decreased with an increase in the body length (see table 3).

## Summary

During the studies of the silver hake spawning efficiency conducted in August-September 1978 on the Nova Scotian shelf dense egg and larva aggregations were observed along the rising and sinking water zones junction west of Sable Island.

In August the total abundance of larval silver hake over the whole investigation area was twice as large as in September and constituted 51,3.10". Hence, in general, the silver hake spawning took place in August.

The total abundance of larval hake over the Nova Scotian shelf was estimated as 35,8.10" in August and 25,6.10" in September.

The length of the larvae fluctuated between 2 and 18 mm. The body length of the larvae from dense aggregations recorded in the Sable Island shoal area averaged to 4.60 mm in August and 5.38 mm in September.

Due to cooling of the surface waters on the Nova Scotian shelf in October 1978 the fry of the hake moved from the shoals to the near-bottom layer of the Nova Scotian trough, where an influx of the water massives of the oceanic origin with the temperature of 6-8°C was observed.

During the study of the silver hake spawning efficiency the water temperatures in the surface layer ranged from 11 to 20°C. A complex water temperature distribution pattern within the 50-100 m layer was evidently related to the influx of warm oceanic waters (up to 20°C) to the southern part of the continental slope and of cold Labrador waters (between 0 and 0.3°C) to the northeastern part of the investigated area. Within the near-bottom layer the water temperature ranged from 5 to 10°C.

In August and September 1978, in the areas of high larval hake abundance the zooplankters of Gen. Oithona and Centropages, and copepod nauplii predominated.

The number of the feeding larval silver hake and their feeding intensity were relatively high both in August and September. The major food components for larval hake were copepodite stages of Paracalanus spp., Pseudocalanus spp., Clausocalanus spp., Oithona spp. and the nauplial stages of these species.

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Table 1

Food composition in larval silver hake stomachs

(August 1978)

| Group of larvae | Mean length of food organisms | Food components | Frequency of occur. | No. of food org. % | Weight, % |
|---|---|---|---|---|---|
| | 0.14 | Copepod eggs | 11.7 | 9.9 | 0.9 |
| | 0.25 | Copepod nauplii | 16.8 | 13.4 | 1.9 |
| | 0.82 | Paracalanus spp. | 15.1 | 7.8 | 11.2 |
| 2.8-5.9 | 1.20 | Pseudocalanus spp. | 3.3 | 0.8 | 3.7 |
| | 1.12 | Clausocalanus spp. | 5.8 | 4.0 | 16.1 |
| | 0.40 | Centropages spp. | 0.8 | 0.8 | 1.3 |
| | 0.62 | Oithona spp. | 13.4 | 9.9 | 2.9 |
| | 0.72 | Non-identified and digested copepodite stages of copepods | 69.7 | 53.4 | 62.0 |
| | 0.15 | Copepod eggs | 25.0 | 14.2 | 1.1 |
| | 0.30 | Copepod nauplii | 25.0 | 16.6 | 3.0 |
| 6.0-8,9 | 0.88 | Paracalanus spp. | 37.5 | 14.2 | 18.5 |
| | 1.10 | Pseudocalanus spp. | 37.5 | 9.5 | 18.1 |
| | 0.60 | Oithona spp. | 12.5 | 2.3 | 0.6 |
| | 0.91 | Non-identified and digested copepodite stages of copepods | 62.5 | 43.2 | 58.7 |

Table 2

Food composition in larval silver hake stomachs

(September 1978)

| Group of larvae | Mean length of food organisms | Food components | Frequency of occur. | No. of food org., % | Weight, % |
|---|---|---|---|---|---|
| | 0.15 | Copepod eggs | 2.0 | 5.1 | 0.5 |
| | 0.26 | Copepod nauplii | 10.4 | 12.7 | 1.7 |
| | 0.76 | Paracalanus spp. | 29.1 | 21.1 | 28.2 |
| 2.0–5.9 | 1.11 | Pseudocalanus spp. | 7.2 | 2.9 | 11.7 |
| | 1.14 | Clausocalanus spp. | 8.3 | 4.3 | 16.6 |
| | 0.80 | Centropages spp. | 1.0 | 2.5 | 3.9 |
| | 0.67 | Oithona spp. | 21.8 | 21.1 | 6.0 |
| | 0.72 | Non-identified and digested copepodite stages of copepods | 43.7 | 30.3 | 31.4 |
| | 0.14 | Copepod eggs | 7.4 | 9.8 | 0.5 |
| | 0.30 | Copepod nauplii | 5.5 | 2.7 | 0.2 |
| | 2.18 | C. finmarchicus | 7.4 | 3.5 | 19.9 |
| 6.0–8.9 | 0.81 | Paracalanus spp. | 25.9 | 20.0 | 14.7 |
| | 1.13 | Pseudocalanus spp. | 11.1 | 9.0 | 18.7 |
| | 1.20 | Clausocalanus spp. | 5.5 | 4.7 | 9.6 |
| | 1.00 | Centropages spp. | 9.2 | 4.3 | 6.1 |
| | 0.66 | Oithona spp. | 22.2 | 16.8 | 2.4 |
| | 1.07 | Non-identified and digested copepodite stages of copepods | 62.9 | 29.2 | 27.9 |

Table 3

Feeding intensity of silver hake larvae (August-September 1978)

| Length of larvae, mm | No. of larvae (August) | | No. of larvae (September) | | No. of food organisms per larva | | Weight of food per larva | | Mean index of food composition (‰) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | food-contain, % | total sp. | food-contain, % | total sp | August | September | August | September | August | September |
| 2.0 - 5.9 | 95 | 85 | 78 | 60 | 2.9 | 2.9 | 0.05 | 0.05 | 638 | 554 |
| 6.0 - 8.9 | 60 | 10 | 58 | 43 | 5.3 | 4.7 | 0.10 | 0.16 | 263 | 533 |

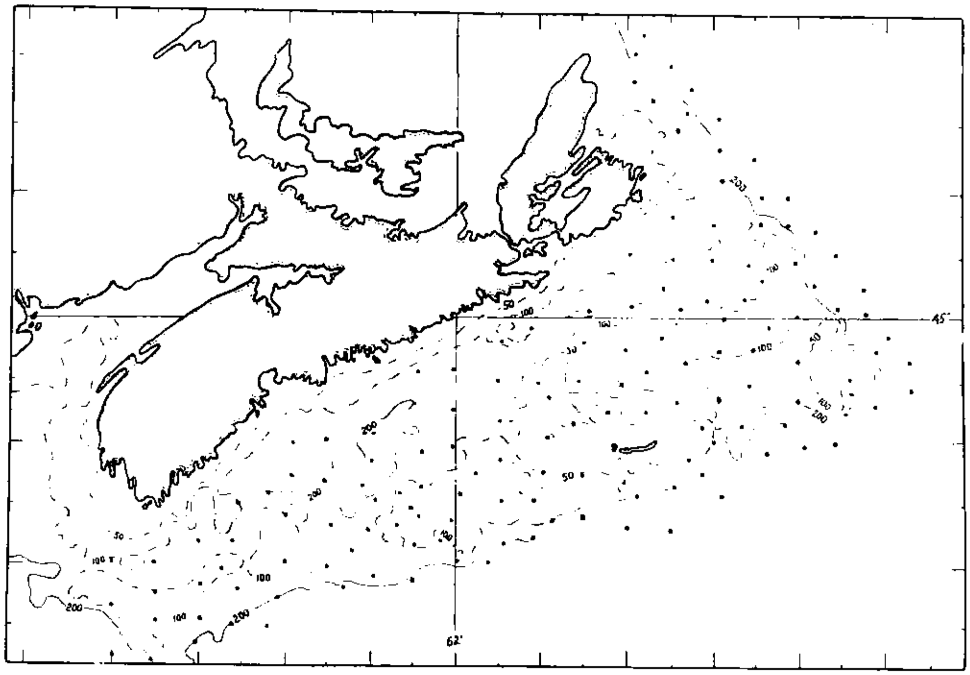


Fig. 1. A scheme of stations in ecological surveys (August-September, 1978).

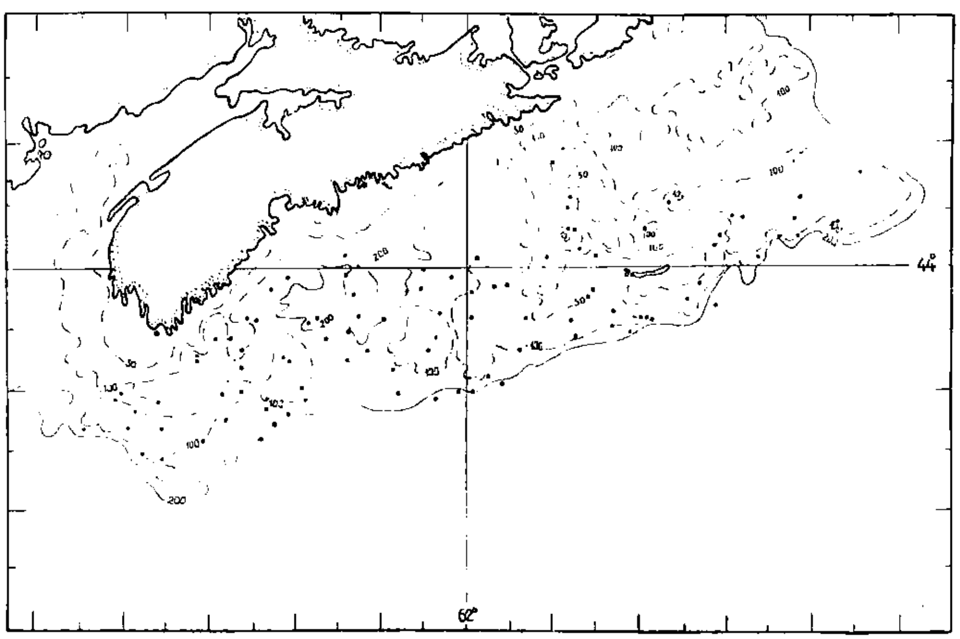


Fig. 2. A scheme of stations in a trawl survey of hake fry (October 1978).

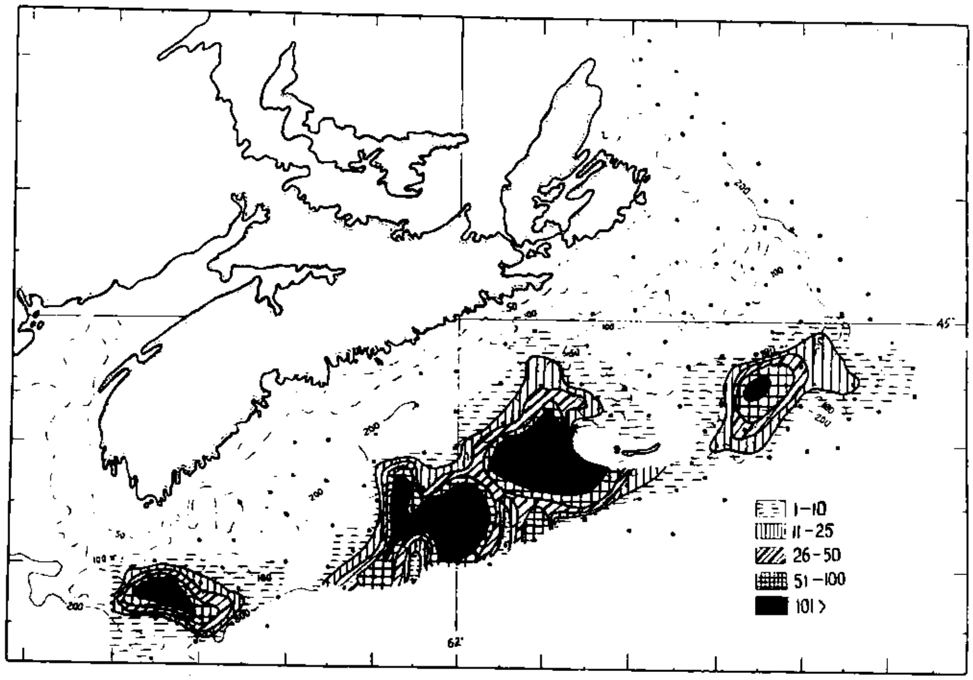


Fig. 3. Distribution of hake larvae (August 1978).

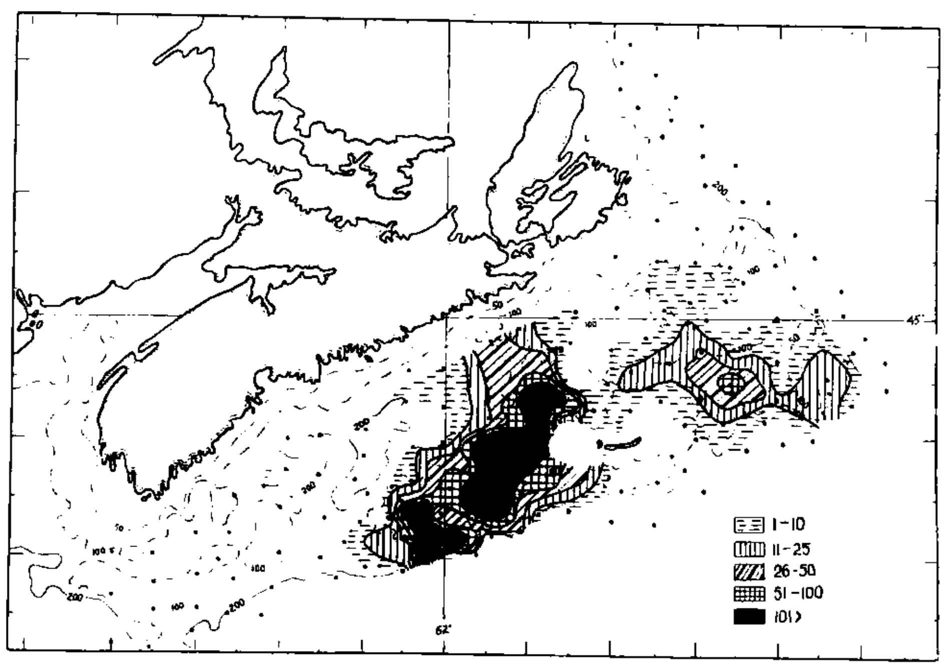


Fig. 4. Distribution of hake larvae (August 1978).

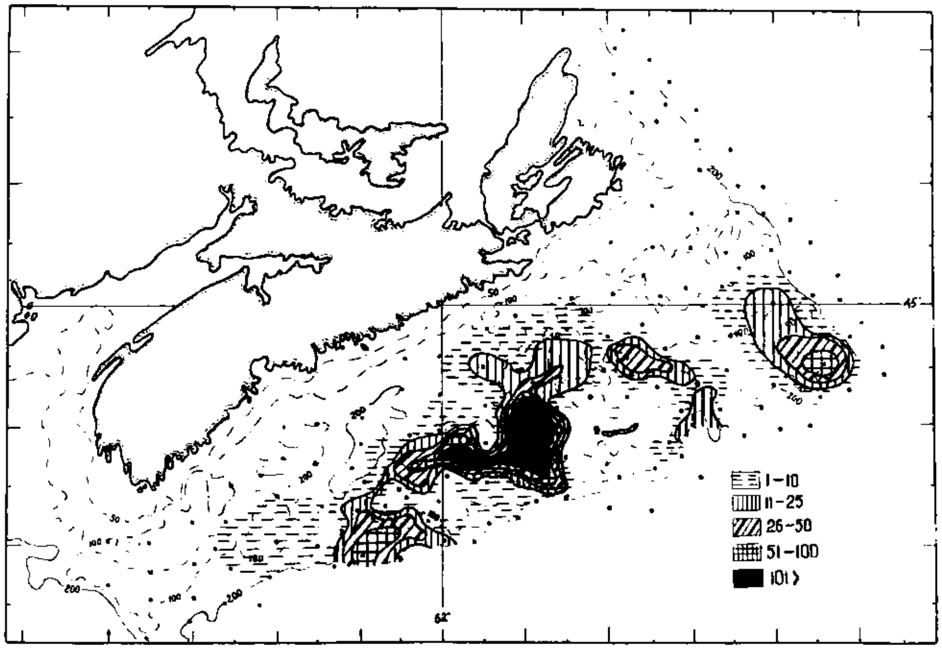


Fig. 5. Distribution of hake larvae (September 1978).

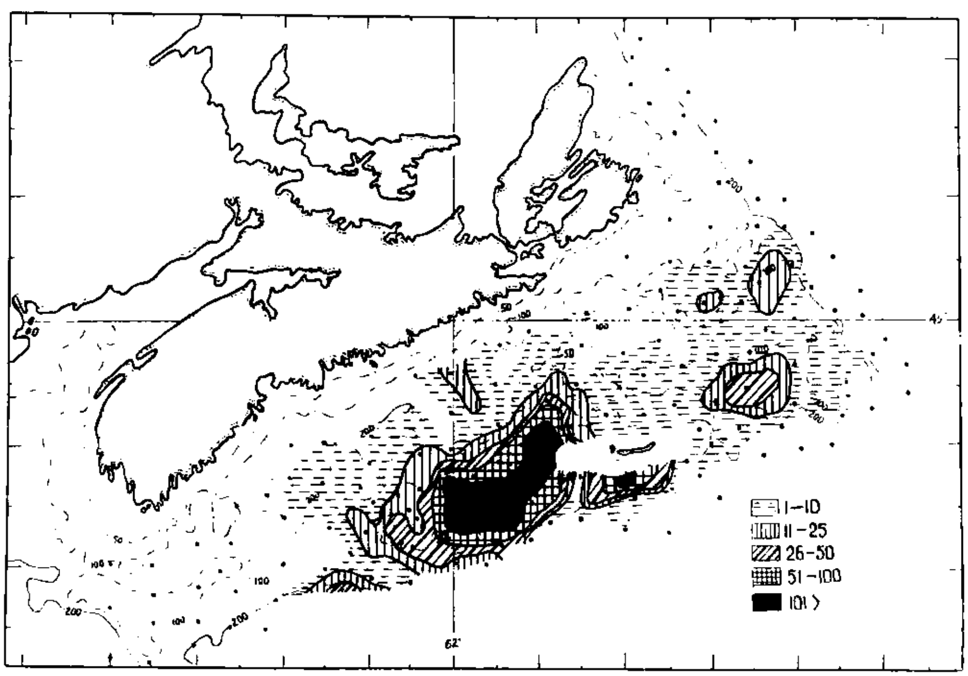


Fig. 6. Distribution of hake larvae (September 1978).

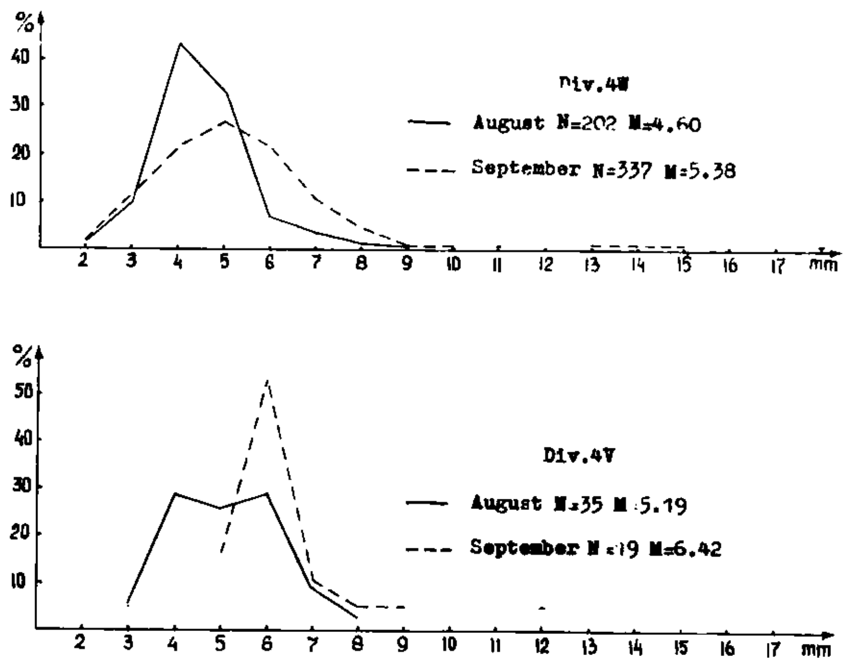


Fig. 7. Length composition of larval hake (August-September 1978).

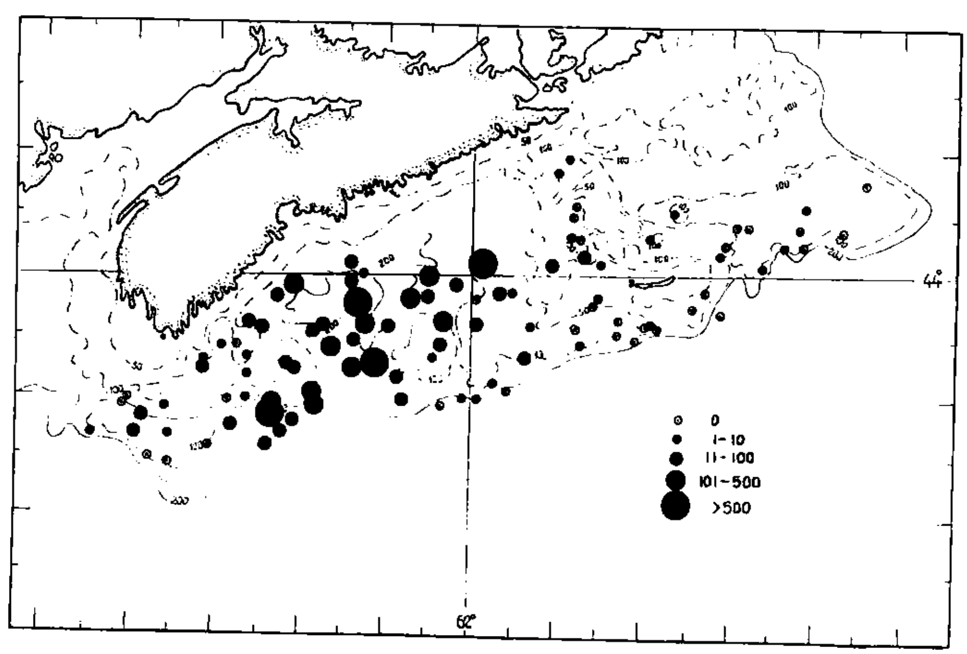


Fig. 8. Distribution of hake fry (October 1978).

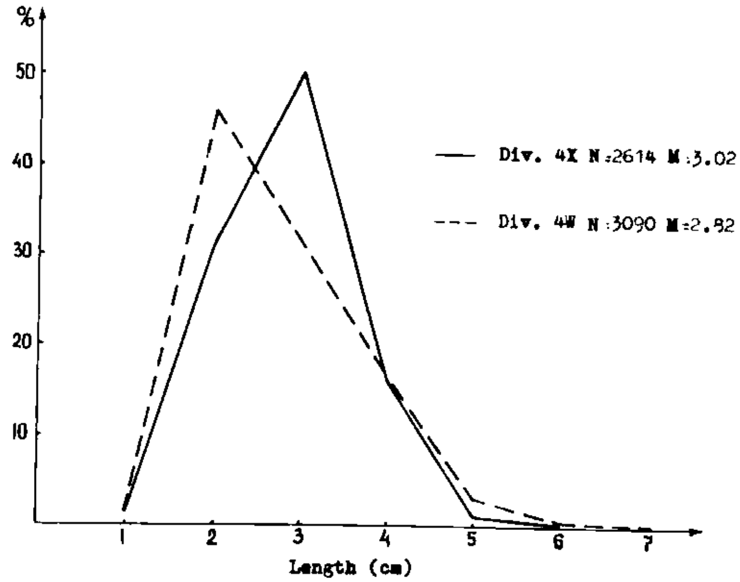


Fig. 9. Length composition of hake fry (October 1978).

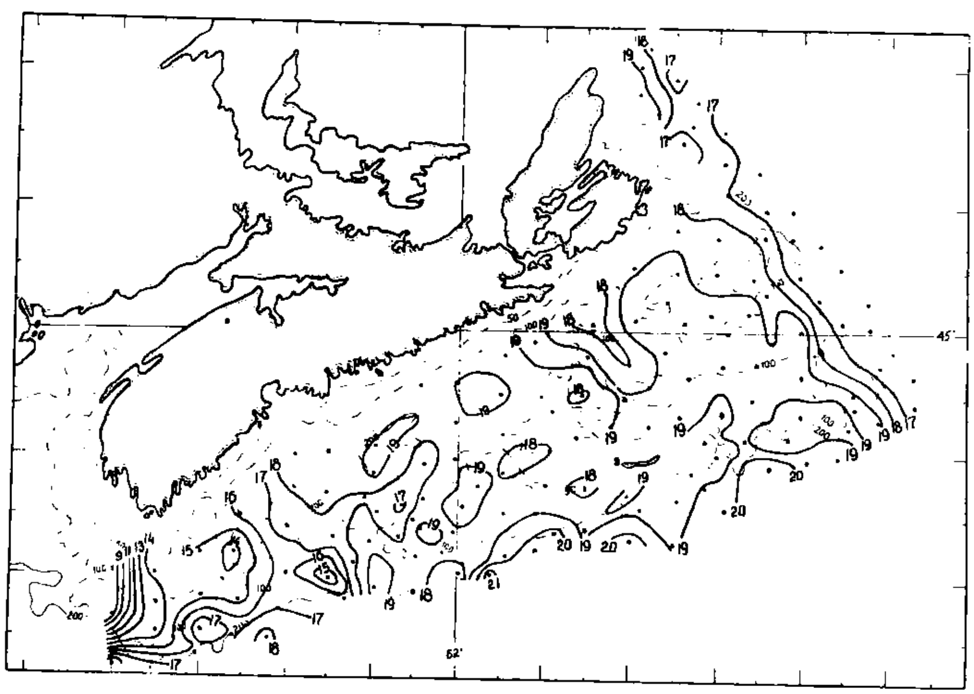

Fig.10. Distribution of water temperatures on the surface (August 1978).

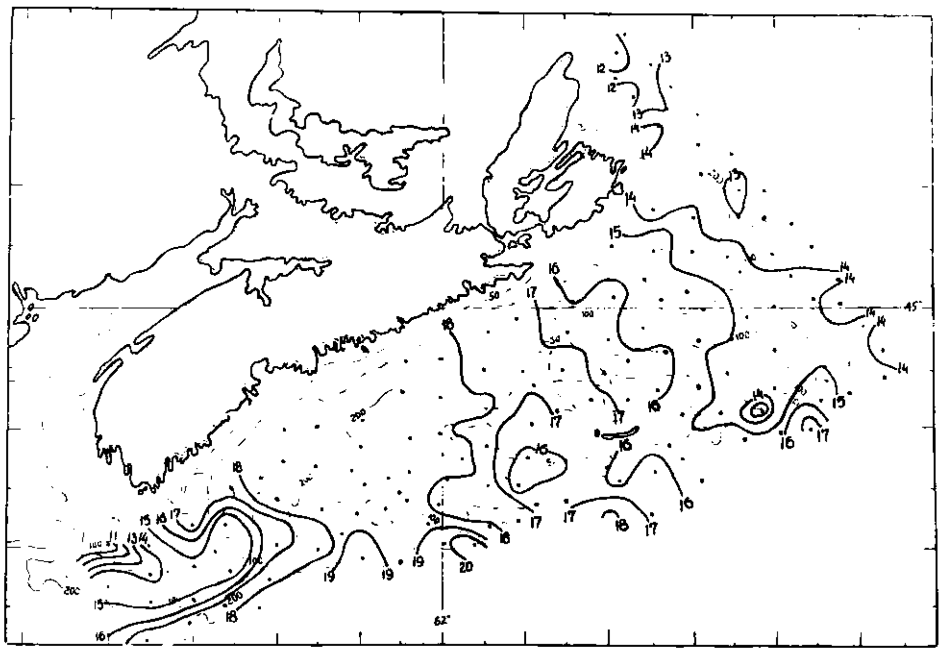

Fig.11. Distribution of water temperatures on the surface (September 1978).

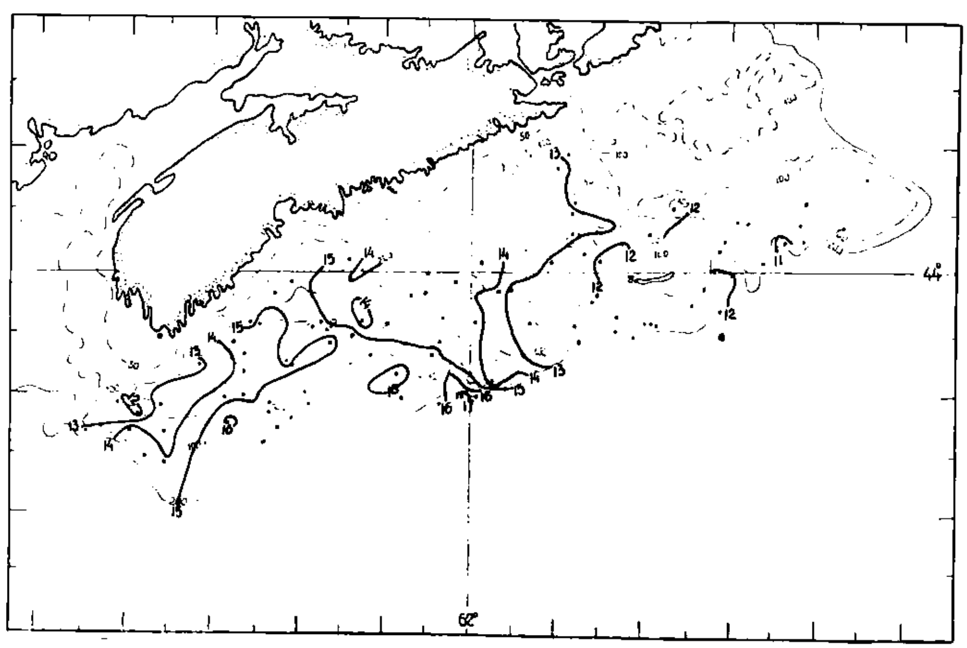

Fig.12. Distribution of water temperatures on the surface (October 1978).

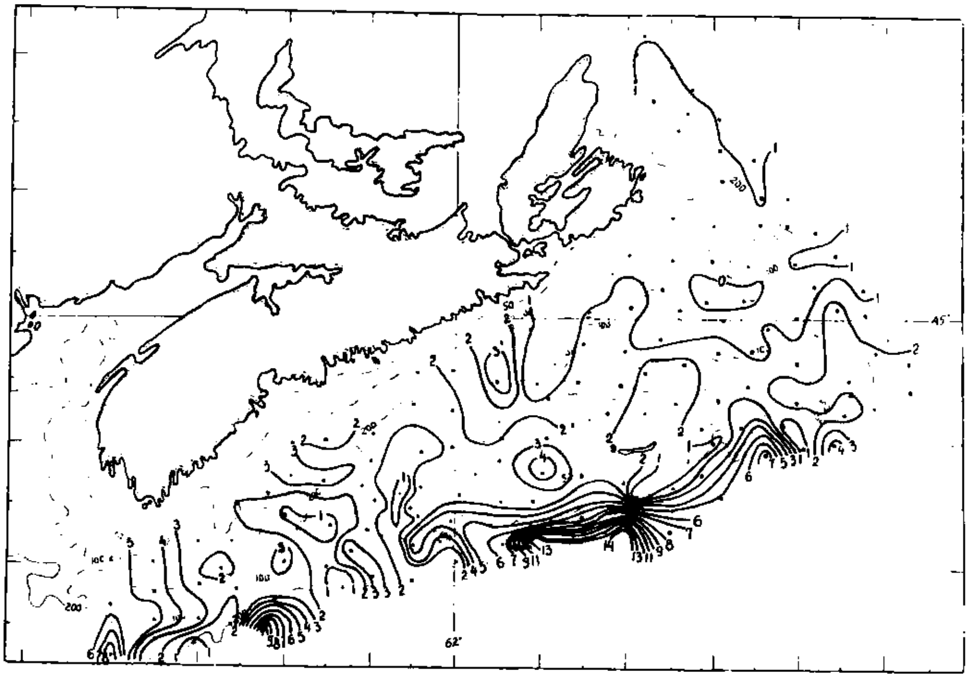

Fig.13. Distribution of water temperatures at the 50 m depth (August 1978).

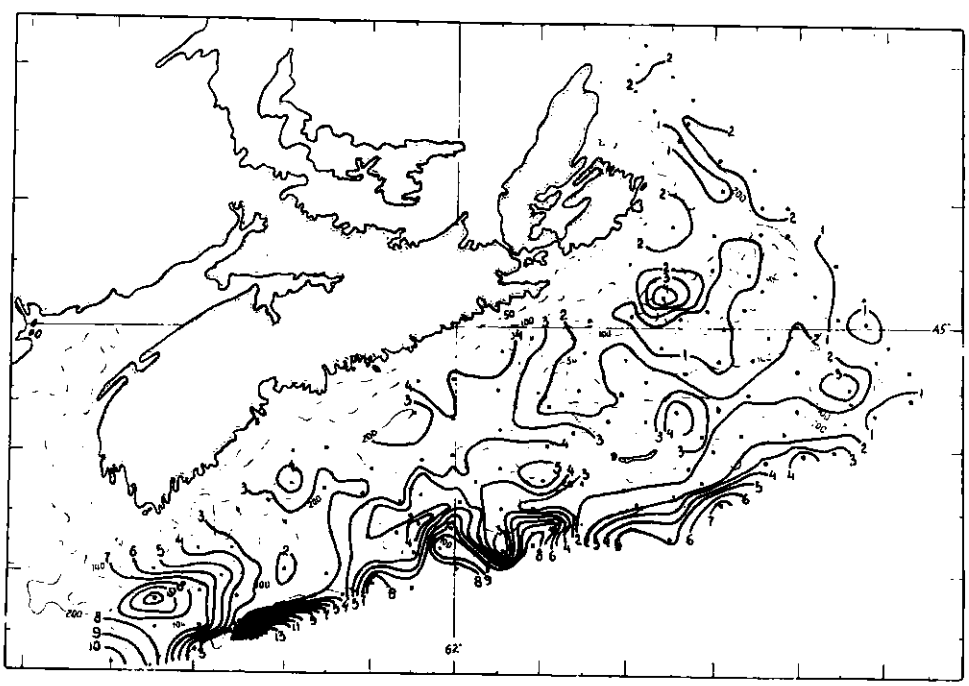

Fig.14. Distribution of water temperatures at 50 m depth (September 1978).

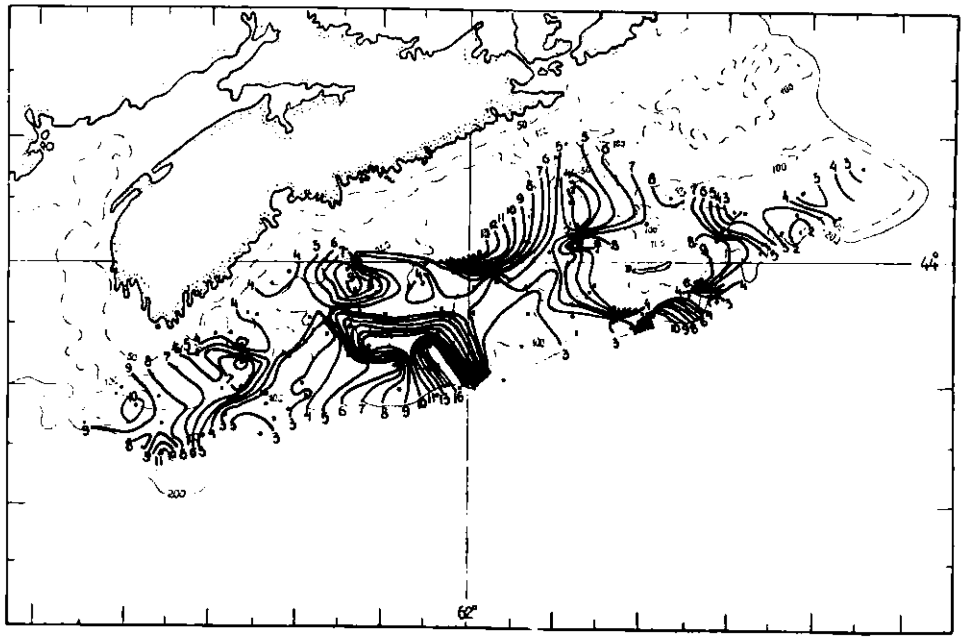


Fig.15. Distribution of water temperatures at the 50 m depth (October 1978).

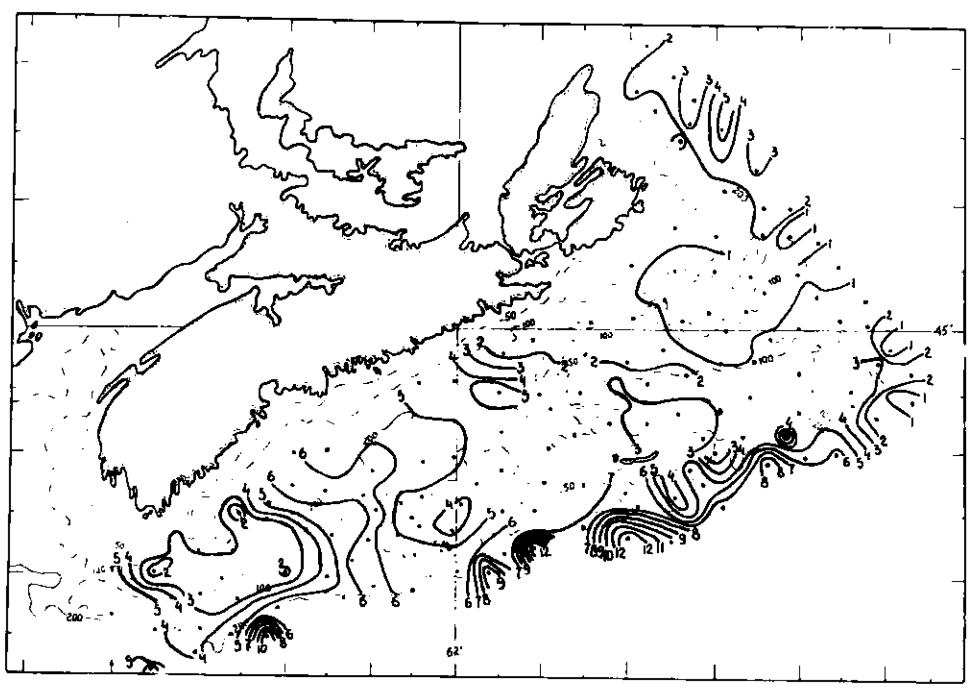


Fig. 16. Distribution of water temperatures at the 100 m depth (August 1978).

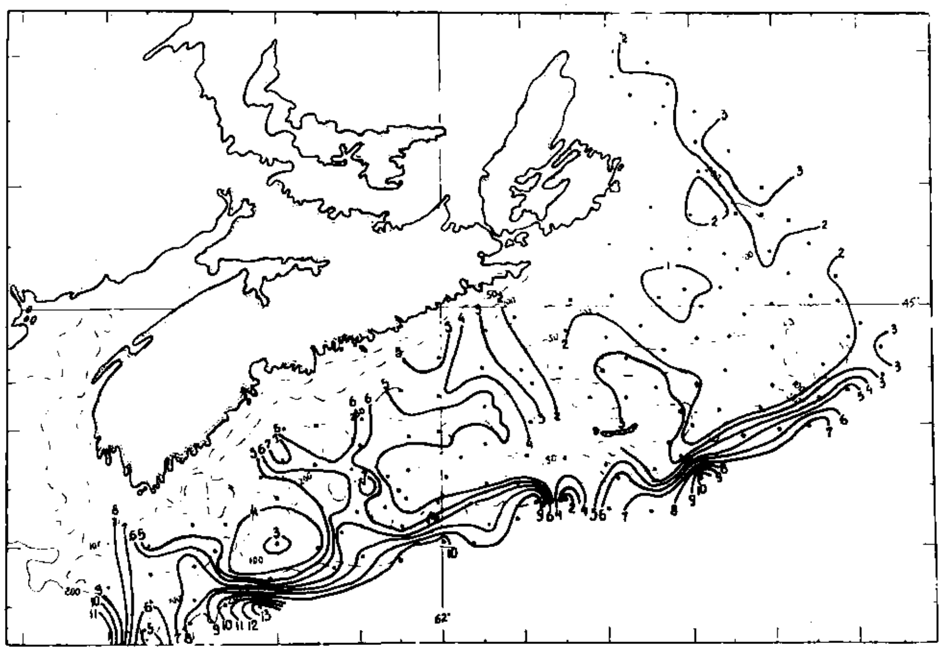

Fig. 17. Distribution of water temperatures at the 100 m depth (September 1978).

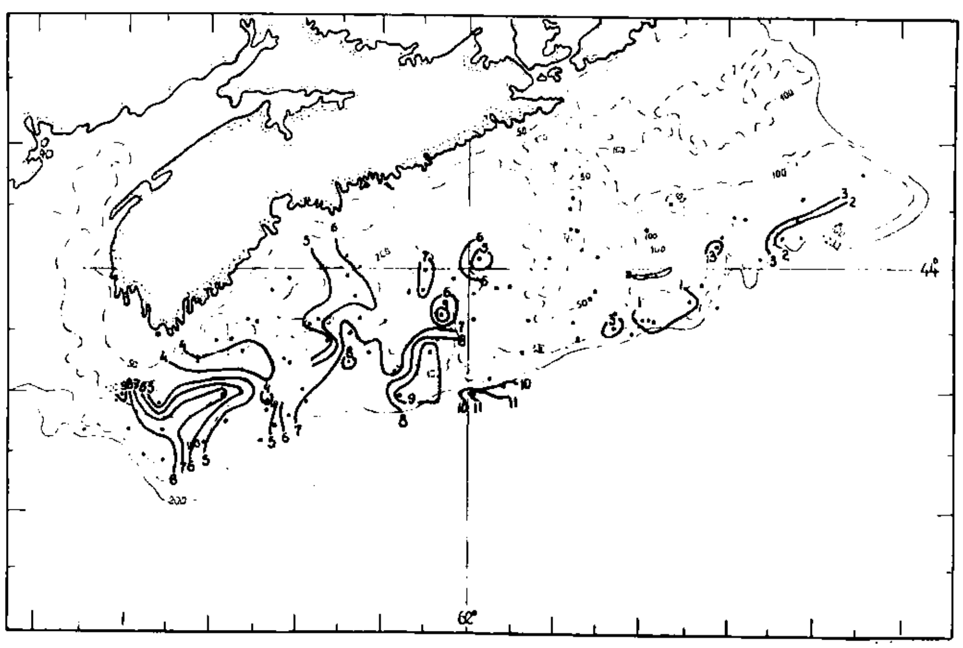

Fig. 18. Distribution of water temperatures at the 100-m depth (October 1978).

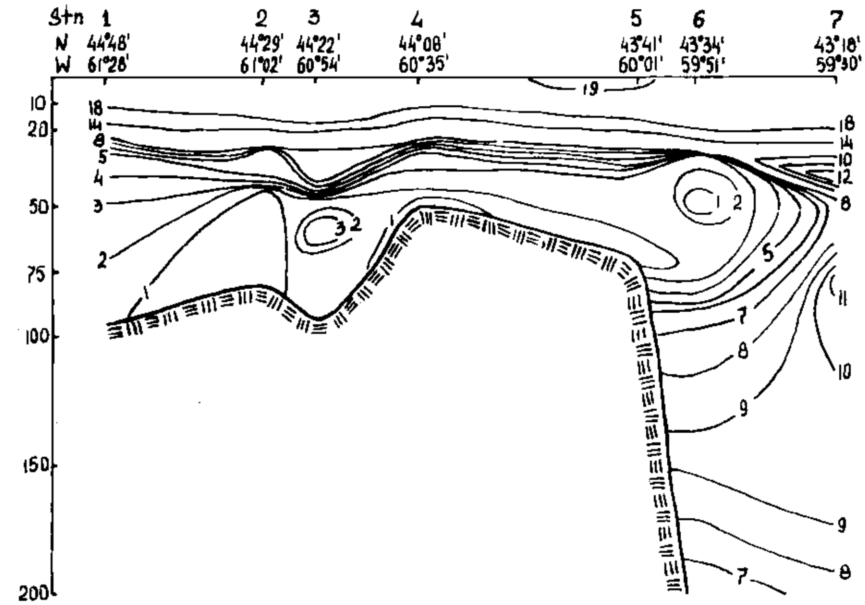


Fig. 19. Vertical distribution of water temperatures at Section 29 (August 1978).

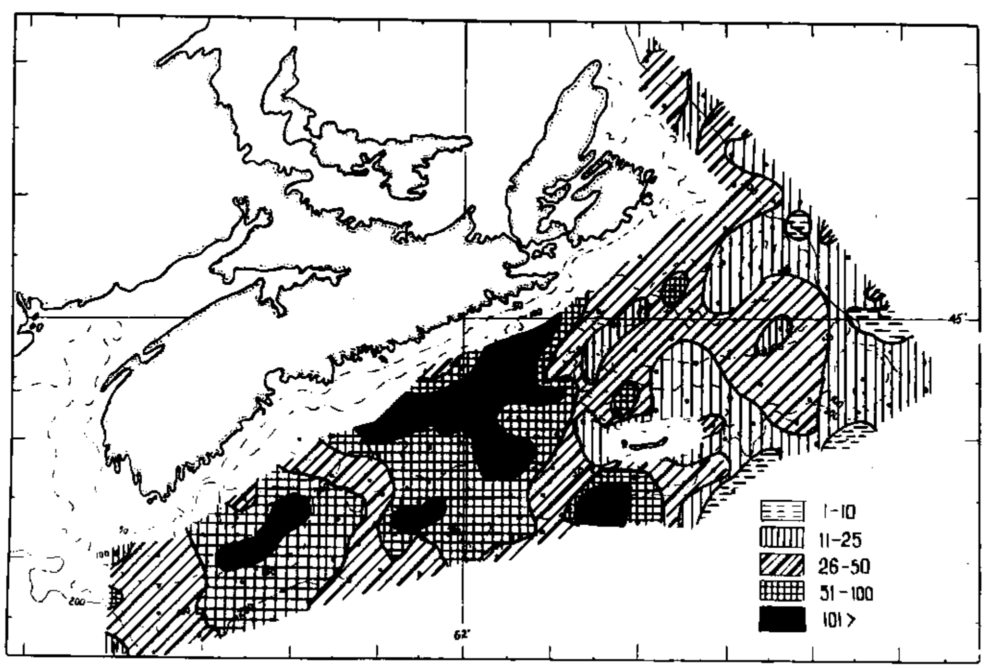


Fig. 20. The seston biomass distribution (August 1978).

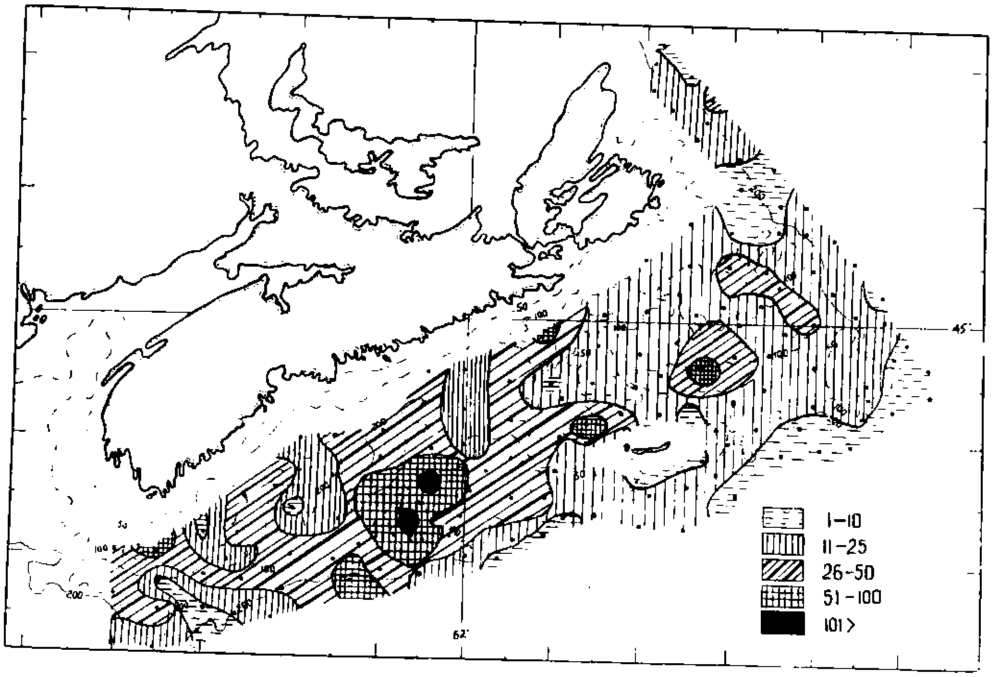


Fig. 21. The seston biomass distribution (September 1978).